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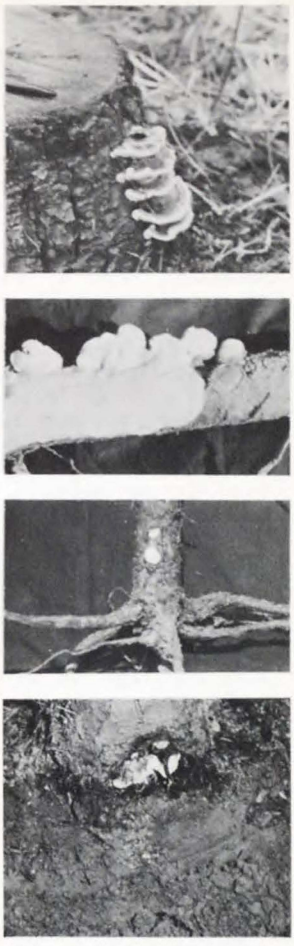

FOMES ANNOSUS

What It Is and How To Recognize It

by Paul V. Mook & Harold G. Eno

The Authors...

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FOMES ANNOSUS

What It Is

THE fungus *Fomes annosus* has caused a great deal of damage to coniferous forests and plantations in Europe. The disease caused by this fungus is now widespread in the United States. In the past few years we have become increasingly aware of its threat in the Northeast. It is particularly damaging to 20- to 30-year-old conifer plantations on formerly cultivated lands, especially those that have been thinned once or twice.

Fomes annosus causes both a root rot and a butt rot. It attacks many species of conifers; occasionally it is found on hardwoods too, although it does little damage to them. This fungus not only does considerable damage as a parasite on living trees, but may exist for many years as a saprophyte. European experience shows that, once forest tree roots become infected, the fungus may survive below ground for 50 years or more.

Symptoms of the disease caused by *Fomes annosus* may differ on various hosts. Damage also varies with host and environment. The fungus assumes many shapes, and its fruiting bodies vary greatly in appearance. Some of the great variability is reflected in the fact that it has been given many names, although at present the proper name appears to be *Fomes annosus* (Fries) Karst. Some of the other names that have been applied to this fungus are *Polyporus annosus* Fries, *Trametes radiciperda* Hartig, and *Polyporus irregularis* Underwood.

The fruiting structures or sporophores of *Fomes annosus* are known commonly as conks. They are so variable in shape and size that these characters are of little or no value in recognizing the fungus. These fruiting bodies vary from small masses or pustules of fungus tissue to bracket-like conks.

The color of *Fomes annosus* conks is fairly characteristic, although it varies from light to dark with increasing age.

The upper surface of the conks varies from a light tan to dark brown or reddish brown. In very young conks, such as one finds in the early part of the season till about midsummer, the upper surface is generally a light tan or

brown color. Later in the season this color becomes a deeper brown, and it is not uncommon to find reddish-brown upper surfaces during late autumn or early fall. The color becomes much darker after the first hard freeze, and conks that have passed through a winter may be a dark chestnut or chocolate brown.

The lower, pore-bearing surface of the fungus is less variable in color. During the active growing season, from spring through most of autumn, the pore surface is pure white. The conks usually have a sterile edge (no pores near the outer edge of the conks), and the margin and outer edge of the top surface may be the same white color. This white lower surface becomes tan to light brown on dried specimens, but even these changes are rather gradual. The pure white undersurface also changes--through tan to light brown to dark brown--after the conks have been subjected to the first hard freeze of fall, or after passing through the winter.

How To Recognize It

Identification of *Fomes annosus* from such variable fruiting structures might seem hopeless. But it isn't. Identification is fairly simple and quite reliable, although the methods proposed here for doing it are not very scientific.

The pores on the underside of *Fomes annosus* conks are fairly large, and their openings can be distinguished by the naked eye. Moreover, the texture and consistency of the fungus fruiting body is characteristic. It is tough, rubbery, almost leathery, and is difficult to tear apart. We know of no other fungus commonly fruiting on conifers and found on conifer stumps, or occurring at the bases or on the roots of living or dead trees, which has this same degree of toughness and resistance to being torn apart. Just a few trials at tearing a *Fomes annosus* conk in half enables one to utilize this characteristic for identification purposes.

Thus, just a few combined characters make field identification of *Fomes annosus* fruit bodies quite reliable. In all probability the fungus is *Fomes annosus*--

- If the suspected fungus is fruiting on a conifer and has a chalky-white under-surface when fresh and actively growing.
- If the pore openings of the pore-bearing surface are large enough to see with the naked eye.

- If the upper surface is tan, or brown, or reddish brown.
- If its texture is such that it is difficult to tear in half because of its rubbery or leathery consistency.

Those who want additional information on the technical aspects of the disease and fungus should consult the abundant European literature. Technical descriptions of the fruiting bodies are available in:

Lowe, J. L. 1957. Polyporaceae of North America--the genus Fomes. N.Y. State Univ. Coll. Forestry Tech. Bul. 80: 85-86.

and

Overholts, L. O. 1953. The Polyporaceae of the United States, Alaska, and Canada. Univ. Mich. Press, pp. 40-42.

Likewise, comments on microscopic characteristics used in determining cultures of the fungus, including the very useful characteristics of the conidiophores, have been purposely omitted. Such information is available in:

Nobles, M. K. 1948. Studies in forest pathology. VI. Identification of cultures of wood-rotting fungi. Canad. Jour. Res. C, 26: 281-431.

Where To Find It

Most *Fomes annosus* conks on conifer stumps, on living or dead trees, are not evident on casual inspection. Fruiting usually occurs at or mostly below the duff surface, where humidity remains high. Fruiting frequently occurs in rodent holes in the soil, duff, or surface litter, or where the duff remains loose and not too heavily packed, such as where large lateral roots branch out, or where the base of the trunk forms an acute angle with the larger lateral roots.

These underground or below-the-duff fruiting bodies are seldom the bracket-like conks such as many parasitic or saprophytic wood rotters form. More often they are irregular uneven masses of fungus. They may be large or small. Often they are resupinate (upside-down), especially the conks in underground cavities of partially tipped over or windthrown trees where the fungus fruits on the underside of roots or root plate.

A few inexpensive tools can be helpful in searching for the hidden conks. Hand weeders, which are available at

garden centers and most hardware stores, will save one much backache and will help prevent ivy poison infections from poison ivy roots severed in digging around trees and stumps. A long-handled weeder has been found very useful for removing duff and loose soil to reveal hidden conks.

Two general types of weeders have been tried for such work. A weeder with tines of spring steel is best where loose duff predominates, because the springy tines are not so apt to tear the conks from the host material. A weeder with stiff, heavy tines is very useful where roots of other woody plants are numerous.

Other useful tools include a shovel, an ax, and a hand-ax.

Locating Infection Spots

Fomes annosus infection spots in conifer stands are often indicated by weed patches. In young infection spots the weeds are mostly herbaceous; in older ones woody weeds predominate. Sometimes the infection spots are associated with small openings in the tree stand; these are often marked by sunny areas, which can be seen from some distance away.

FIGURE 1 shows an infection center in a red pine stand. The weedy growth in this 8-year-old infection spot is mainly wild cherry. The age of infection spots may be roughly indicated by the sequence of the weed invaders found on them. The tops of the dead trees can be seen on the outer edge of this circular infected area. On an active infection center one can often see dead trees bare of needles, the reddish-brown dead needles still retained by recently killed trees, and the greenish-yellow or yellowed needles of severely infected and almost dead trees. However, such top symptoms are not visible very far away because they are screened by uninfected, healthy trees--unless, of course, infection spots are on the edge of a conifer plantation. The important things to look for are sunny areas or green weedy growth, for one can see such patches through the tree stems for a good distance.

FIGURE 1

FIGURE 2 shows a typical infection spot in an unthinned red pine plantation. This is a younger and smaller infection area than that shown in Figure 1. The sunlit area contrasts against the darker forest floor of the uninfected stand in the background. Here the weedy patch is composed mostly of herbaceous plants. Here there is a tendency toward zonation of the weed patch: dense in the center and comparatively weed-free around it. Note the fallen uprooted trees in the foreground; such windthrown trees are common in infection spots. Stumps of recently cut dead trees--like that in the foreground--are frequently seen in the outer part of infection centers where weed invation is comparatively light.

FIGURE 3 shows a *Fomes annosus* infection center is in a mixed red pine-Norway spruce planting. Here too one can see the weed growth, the sunlit spot of the original infection center, and the stumps of recently cut dead trees in the foreground. Windthrows of root-rotted trees are evident on the edge of the dense weed growth. The weed invasion is thin or absent on the edge of this infected spot where trees were recently killed.

Once infection centers have been located, they should be examined for the fruiting bodies of the fungus. In the three areas shown in Figures 1, 2, and 3, *Fomes annosus* infections were found by removing duff from around stumps and trees suspected of being infected.

Exposed Conks

BRACKET-LIKE FORMS

The bracket-like conks of *Fomes annosus* are usually easy to see because of their size and the fact that they are formed just above the duff surface or on a level with it. They are not so apt to be hidden from view as the abnormal fruiting structures often are.

The fungus usually forms bracket conks where quite a bit of shade occurs, such as on the edges of infection centers, or where advanced prongs of infection have penetrated beyond the general margin of the infection center. Bracket forms are also found in the center of old infection areas on old stumps, but in such cases under the rather dense shade from an overgrowth of herbaceous or woody weed cover.

FIGURE 4 illustrates a typical bracket-shaped *Fomes annosus* conk on red pine. It was produced at the duff surface, which has been removed to show the fruiting body in its entirety. Before the foreground litter was cleared away, the conks were not so conspicuous, because the light brown upper surface blended with the color of the duff surface. The conks have uneven, wavy edges. A number of red pine needles have become embedded in the conks as they grew. This is characteristic of *Fomes annosus* conks.

FIGURE 5 shows some unusually large *Fomes annosus* conks fruiting on a low-cut red pine stump. These conks are on about the same level as the duff surface, and their light brown color matches the color of the pine straw. This stump was in the midst of trees showing no signs of infection, but near the edge of a badly infected area, of which it was an extension. Nearby trees shaded the infected stump. It is unusual to have *Fomes annosus* fruiting on the stump surface, as the center conk is; this is a condition that sometimes occurs in heavy shade. The very low cut was favorable for such fruiting because it had been made almost at ground level, as indicated by the pine needles partially covering the stump as well as the conks.

FIGURE 6 illustrates other aspects of bracket forms of *Fomes annosus*. For example, note the irregularities in the large conk cluster on the right. It is partly resupinate, its reflexed upper part forming a bracket-like extension of the conk cluster. Note also the imperfect bracket-like form of the smaller conk on the left. This is intermediate to and approaches the pustule-like masses of fungus tissue which commonly form the abnormal fruiting bodies of *Fomes annosus*. Both fruiting masses were just about level with the duff surface; in fact, the one on the left was mostly buried in the duff. The duff litter has been cleared away to afford good views of these fruiting bodies.

FIGURE 7. The conks shown in this photograph are unusual in several respects. The series of conks on the right are unusually symmetrical (the conks are seldom arranged in series as they are here). Also, they were borne above the litter layer. Being formed above the litter layer, they are more suitable for wind distribution of spores than most *Fomes annosus* conks are. Note the irregular conk on the lower left. This, like the one shown in Figure 6, approaches the pustule-mass form of abnormal conks.

(The term "abnormal," in the case of *Fomes annosus*, is a comparative one only; for such abnormalities are the normal state with fruiting structures of this species and are characteristic of the fungus. The abnormality is the underlying reason for the great variability in the fruiting bodies of the species.)

All these bracket-like forms of the fungus fruiting bodies were fresh and actively growing. All of them show the white sterile margin mentioned earlier. This white sterile margin is another characteristic of the bracket-like conks.

Conks Hidden by Duff

Fomes annosus fruiting bodies are often hidden completely below the duff surface at the base of the tree or on some of the larger lateral roots. This below-the-duff fruiting usually occurs as irregular and abnormal fruiting bodies that vary greatly in size and shape. Such fruiting appears to be more common with some species of conifers than others. It is common with white pine, loblolly pine, Norway spruce, and Douglas-fir, especially on infected standing trees, both living and dead.

BUTTON OR PUSTULE-LIKE CONKS

Abnormal forms of *Fomes annosus* fruiting are often associated with early phases in the development of the fungus. Environmental conditions also influence the variation in the fruiting structures of this fungus. When *Fomes annosus* first makes its external appearance on infected wood, the fungus mass is small. Often it is a small hemispherical mass. These resemble buttons.

As the buttons of fungus grow they may form irregular pustules. If ample moisture and other favorable environmental conditions are present, the buttons or pustules may develop into the bracket forms. If hot dry weather of midsummer follows good growing conditions of early spring, the fungus is apt to grow very slowly by forming irregular masses of pustules.

Fruiting bodies formed under the duff, in soil cavities, on the roots, or beneath the root plate, seldom produce the bracket forms. Underground fruiting is usually some variation between the button or pustule forms and the *Poria*-like form. The *Poria* form is a resupinate conk in which the exposed outer side is practically all pore-bearing surface.

It appears that the conifer host influences the appearance and kind of fruiting structure that develops. For instance, red pine--a very susceptible species--is more apt to develop bracket-like forms than either Douglas-fir or loblolly and white pine. *Fomes annosus* infections of these latter species show a distinct tendency to produce the resupinate, *Poria*-like root conks and are less apt to fruit on the tree base or stump.

FIGURE 8 shows two very small, white, button-like conks of *Fomes annosus* on the base of this recently dead loblolly pine seedling. They appear as two small white dots. Both of these small white conks are the very early stages in the development of fruiting bodies. The button conks may vary from pinhead size to the size of a half dollar. Larger ones are usually pustule-like. They are tough, rubbery, or leathery in consistency and very difficult to tear apart.

This seedling was killed by fusiform rust. No *Fomes annosus* fruiting was found on nearby healthy seedlings. In this locality it appeared that *Fomes annosus* attacked only the naturally seeded loblolly pines that had been weakened or killed by the rust. However, resupinate conks of *Fomes annosus* were found on large windthrown loblolly pines in the same vicinity.

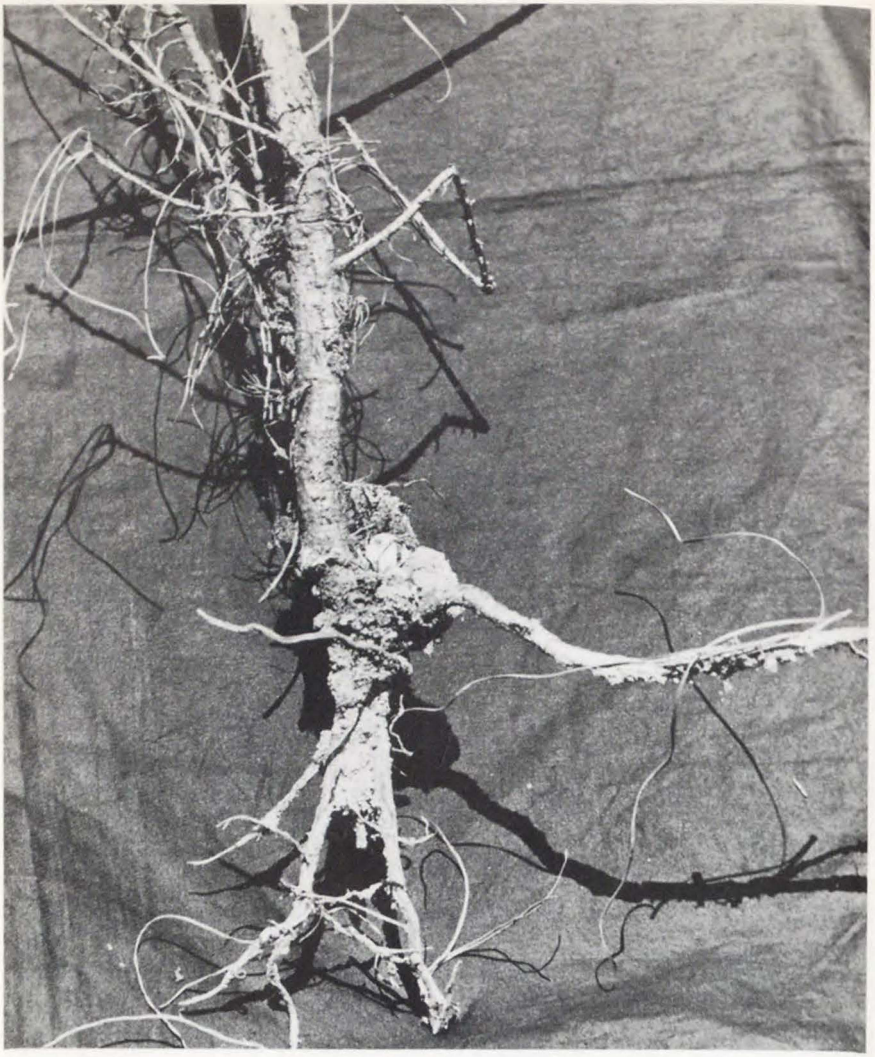


FIGURE 9. The pustule-like mass of fungus tissue on the root collar of this loblolly pine seedling is an abnormal fruiting body of *Fomes annosus*. Many times, especially in dry weather, the button-like form (fig. 8) develops into such pustule-like masses. They often contain varying amounts of poroid tissues, which occur as twisted, jumbled, Trametes-like pore layers.

The dirt near this pustule-like fruiting mass, and below it on the roots, is sandy soil fused with pitch. The roots of many *Fomes annosus*-infected conifers show similar pitch-soil fusions at some place on their root system. They may incrust portions of certain of the roots, or appear as balls of

dirt-infused pitch. Such pitch balls, or incrusted roots, are indications of *Fomes annosus* infection. Sometimes pitch balls occur in the absence of *Fomes annosus* fruiting. When *Fomes annosus* fruiting is absent, the presence of pitch balls should be interpreted cautiously, because certain insect infestations may also cause them to form. In such cases, the suspected root material should be cultured to isolate the fungus.

FIGURE 10 shows the other side of the same loblolly seedling. This emphasizes that the pustule-like fruiting is a spherical fungus mass. Note again the pitch-infused soil around the roots.

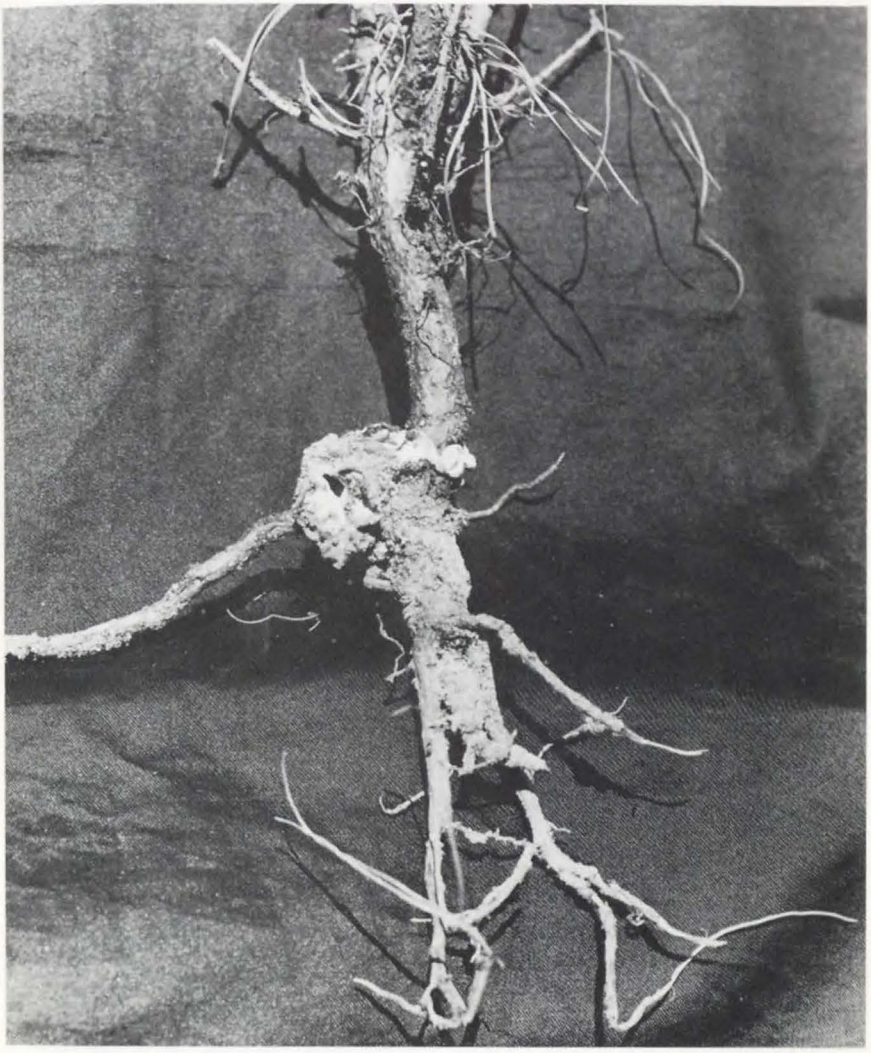


FIGURE 11 shows *Fomes annosus* fruiting on white pine. Note the two small buttons or pustules of fungus tissue. There is another small pustule on the right side of the large lateral root at the lower left of the photograph.

All these conks were buried at least 4 inches below the surface of the duff, which has been removed to reveal these abnormal fruiting masses. They were about 3 months old. If these buttons were to remain small and if growth were not resumed next year, they would become dark brown and almost impossible to find.

It is believed that some trees infected this way may live for many years, some may even throw off the effects of the disease; others may succumb rapidly. In this case, we cannot predict.

FIGURE 12 shows several small and irregular *Fomes annosus* conks on a standing dead red pine. Most of them are pustule-like structures. All were buried under the duff layer. Many red pine needles are embedded in the conk tissue.

FIGURE 13. *Fomes annosus* fruiting on a dead white pine twin tree. The small white conk below the dead basal stub is similar to ones shown previously; but the cluster of fruiting structures on the large lateral root at the left have both pustule-like conks and a crustose type of fruiting body.

These crustose formations are quite different from the typical Poria-like resupinate sporophores, which will be shown later. The white margins of the crustose conks denote the recent growth of the fungus. The center of the crustose conk is brown, relatively inconspicuous, and was formed the previous year. The whitish growth shows that these conks remained viable and resumed growth this season.

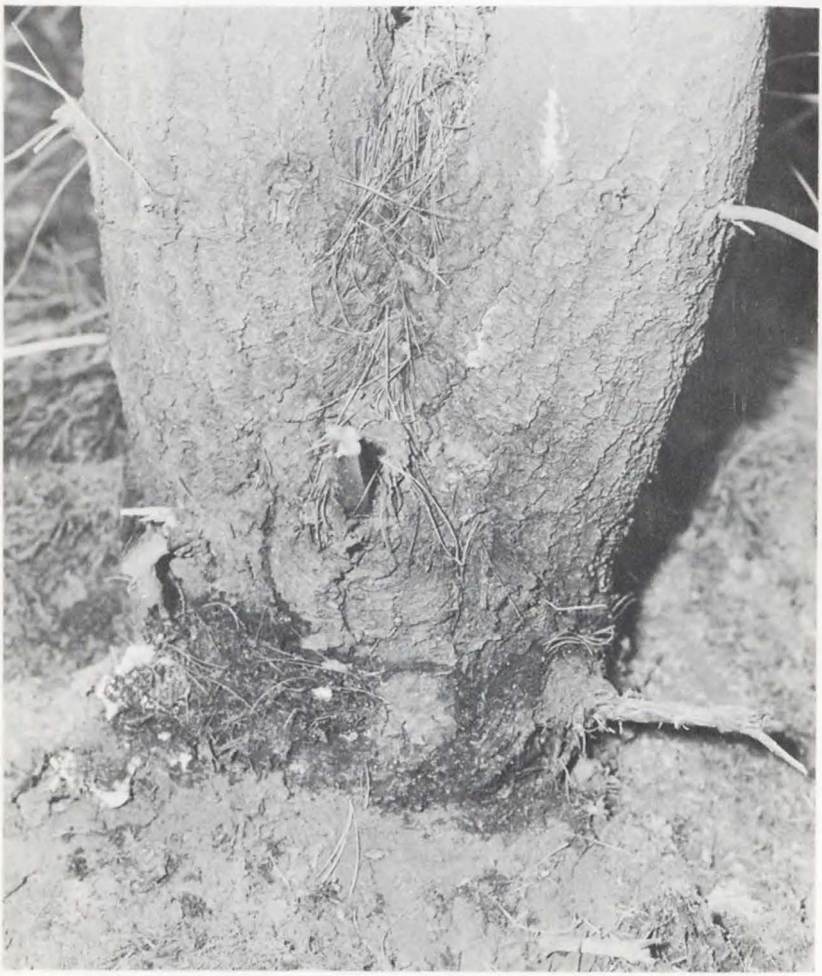


FIGURE 14 is a good illustration of the crustose-like fruiting of *Fomes annosus*. Here it occurred on top of a lateral root of a living white pine tree rather than on the tree base. This crustose conk had no pore-bearing layer. However, it was of recent origin and its further development might well have produced a pore-bearing layer.

It is difficult to predict the trend of such an infection. If this tree has unusual vigor it may outgrow the infection and incur little damage. If the infection continues to be severe the tree may die within 2 or 3 years.

BRACKET-LIKE FORMS

FIGURE 15. This large, thick, and irregular bracket-like conk fruited on a living white pine. Note the white margins and the light brown upper surface. Pores were well developed on its lower surface. The size and thickness of the conk indicates a relatively severe infection, as does its location; and we suspect that this tree will die soon.

FIGURES 16, 17, and 18 show variations of the plate-like bracket forms of *Fomes annosus*. All of them occurred on dead standing white pines. It appears that conks formed after trees have died, or on stumps, are usually much larger than those that form on vigorous living trees. Each of these examples possesses some special features explained below.

FIGURE 16. *Fomes annosus* conks are often perennial, a feature that places them in the genus *Fomes*. Both conks shown here are more than 1 year old. The darker portions of the upper surface were formed prior to this season, the white margins are renewed growth. The lower surfaces of these conks were poroid. The larger size of the fruiting bodies, the completely dead tree, and the perennial conks are indicators that this infection was not recent.

FIGURE 17 shows an exceptionally large plate-like bracket conk of *Fomes annosus*. In other respects it is similar to that shown in Figure 16. A white fringe of fungus tissue extends from both sides of the conk along the base of the tree. This is new external growth, which consists of a line of pustule-like formations of the fungus. This white pine host recently died from the effects of the fungus.

FIGURE 18. The larger plate-like bracket conk shown here is mostly this year's growth. The upper surface is light rather than dark brown, which indicates more recent origin than those shown in Figures 16 and 17. Another point of interest is that this conk formed at the tree base in an angle between two large lateral roots. In such a location the overlying duff is less densely packed and fungus development occurs in a sort of pocket formed by the adjacent roots. Very often fruiting bodies are found in such locations on infected trees. The large fungus pustule on the right is of very recent origin and is growing rapidly.

FIGURES 19 and 20. These two photographs of a white pine that had been killed by *Fomes annosus* illustrate dramatically the contrast between the upper and lower surfaces of the fungus conks.

In Figure 19 one can see a small whitish mass on the right; it is this year's new growth of fungus. At the lower left there is a dark brown lobe of fungus growth. These were the only fungus bodies noticeable after the duff had been removed. There is much more fungus growth here than meets the eye; but the dark brown color of the fungus blended so well with its background that its extent was not suspected.

In Figure 20 the fruiting body has been removed from the tree, but reversed to show its lower surface. The presence of the connecting strands of fungus were unsuspected till the conk had been removed from the tree. Most of this very irregular conk is old growth.

Underground Fruiting

Underground cavities apparently create a microclimate that favors the development of *Fomes annosus*. There is good reason to believe that rodents may play a part in the distribution of the fungus. Soil cavities should be examined, for the fungus may be fruiting in them.

IN RODENT HOLES

FIGURE 21 shows indications of a rodent hole in the duff at the base of a living white pine tree.

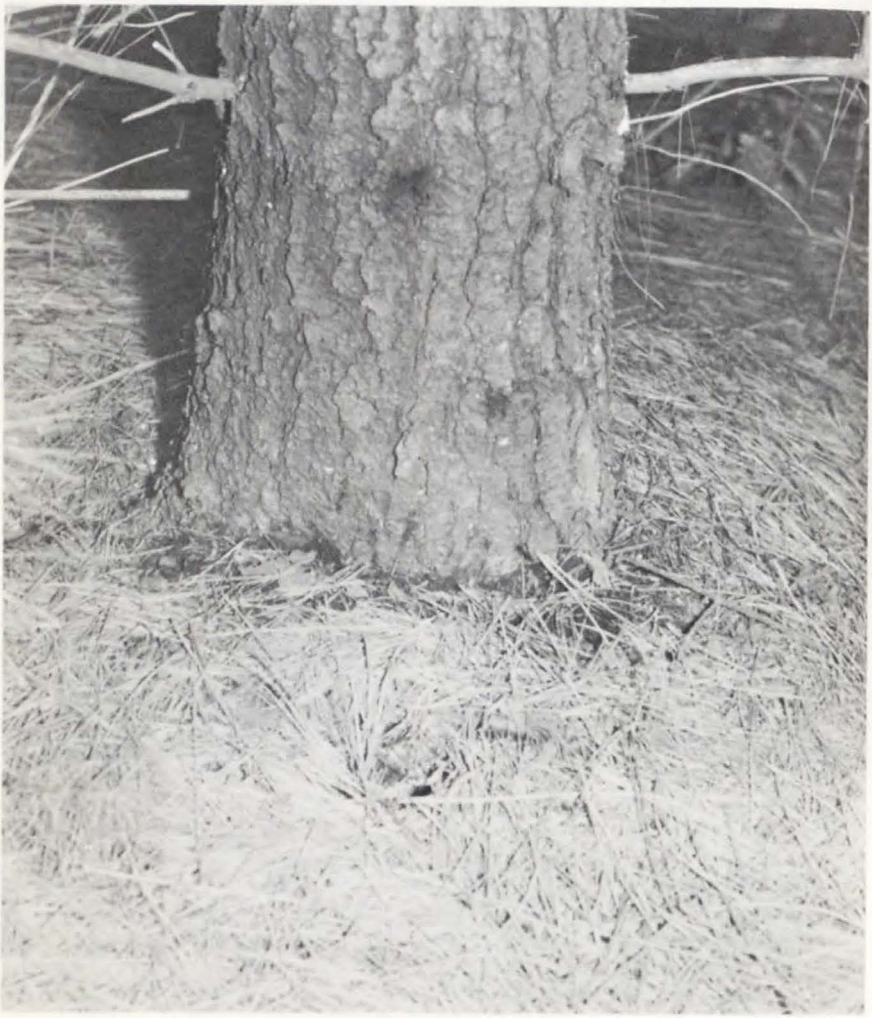


FIGURE 22. A few loose pine needles have been removed to reveal the rodent hole.

FIGURE 23. Suspecting the presence of infection here, we cleared away the duff and some soil--and found the plate-like bracket conk fruiting on the base of the tree.

The number of windfalls is related to the extent to which tree root systems have been weakened by root rots. Partially or completely windthrown trees often create soil cavities that are conducive to *Fomes annosus* fruiting, if the disease is present. Such trees and soil cavities are good indicators that root-rotting pathogens may be present.

FIGURE 24 shows a partially tipped over dead white pine tree in a *Fomes annosus* infection center. The curtain of weeds, weed roots, and adhering soil obscuring the soil cavity behind it has been partially removed to show the cavity. A white resupinate conk of *Fomes annosus* can be seen on the under side of the root system. It is surprising how often the fungus can be found in conifer plantations by investigating windfalls.

FIGURE 25. This is the same tree, tipped over still farther. Additional dirt and weed growth were removed to afford a better view of the very large resupinate fungus conk.

FIGURE 26 shows a closer view of the stump roots and the *Fomes annosus* fruiting. The very white, fresh-looking sporophore attests to its recent formation.

Resupinate fruiting forms of *Fomes annosus*, as shown here, consist of an outer surface which is a pore-bearing layer that is characteristic of the genus Poria. When *Fomes annosus* fruits on roots, or on wood lying on the ground, the fruiting bodies are most commonly resupinate. There is also a very small, white, round, resupinate conk just to the left of the large one. The frayed ends of the rotten roots may also be seen.

Resupinate Forms

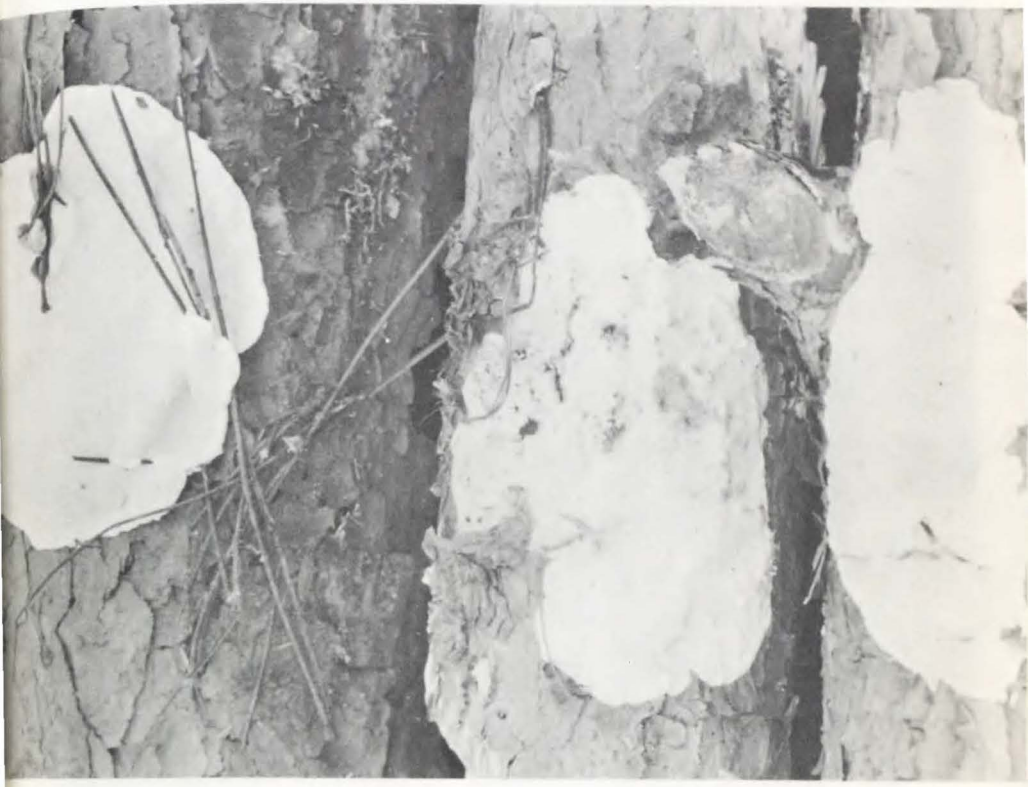
In some situations--for example, on down wood in contact with the ground, and on roots of infected conifers--*Fomes annosus* develops resupinate conks. In contrast to the bracket-type conks, in which the pore-bearing surface is on the underside, the resupinate form is attached to the wood surface on one side and its pore-bearing surface is on the exposed outer side of the fungus.

ON ROOTS

FIGURE 27 shows four resupinate *Fomes annosus* sporophores on this Douglas-fir stump. When this dead Douglas-fir was blown over, the rotted stump split, leaving a 2- or 3-inch crack separating it from the remaining portion of the stump. A cavity in the soil was produced when the tree became windthrown. Note the white-speckled, mottled wood of the stump and how thoroughly rotted the roots and stump of this tree is. All *Fomes annosus* fruiting on this infected tree occurred on roots or on the basal part of the stump. None occurred at or near the duff surface, as it often does on trees in infected red pine plantations.

ON DOWN WOOD

FIGURE 28 shows some typical examples of resupinate *Fomes annosus* fruiting bodies found on down wood. They were on red pine bolts piled on an infected area. Bolts in contact with the ground, or close to the ground near the bottom of the pile, had a number of *Fomes annosus* resupinate conks on them.



Other piles of wood on the same heavily infected area were dismantled, and at least a few bolts had similar resupinate conks on them. At this locality the wood had been piled on the infected area for at least one full growing season. Some similar piles of wood within 200 feet of the infection spot, and others yet more distant from it, were dismantled and carefully examined, but not a single conk was found. Most conks of this type are circular in shape, but some are elongated, and others quite irregular. All are *Poria*-like.

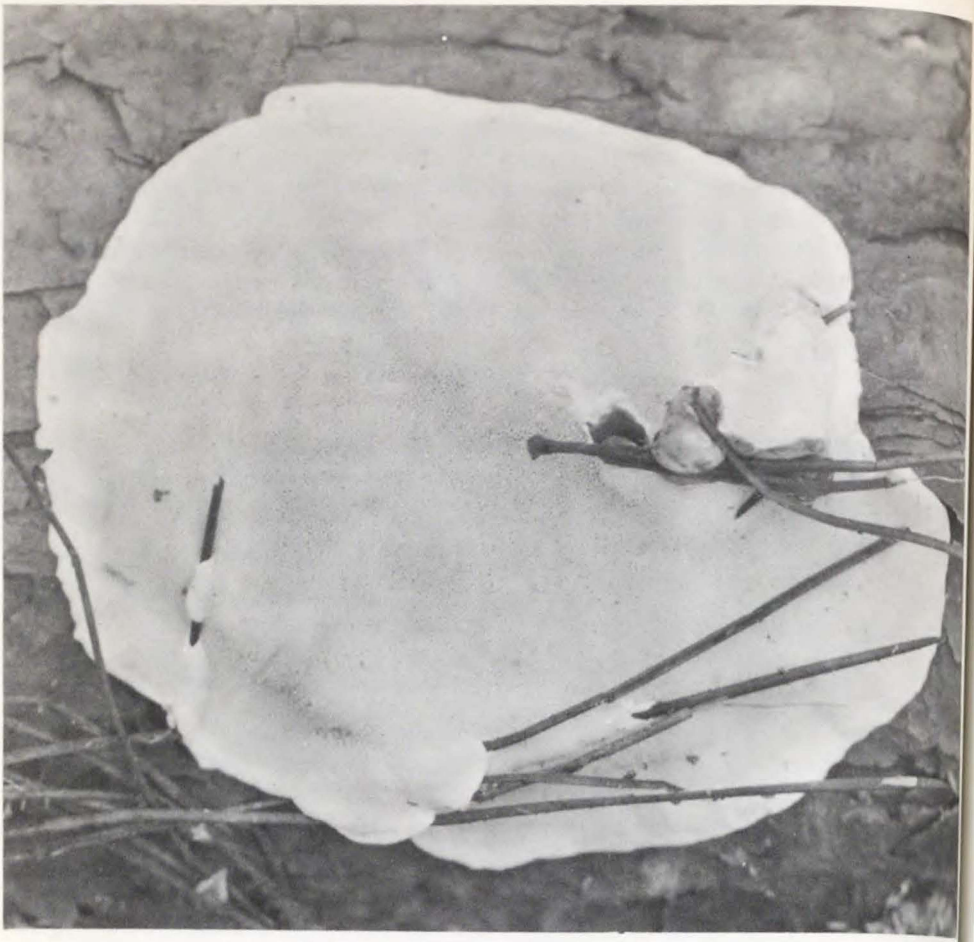


FIGURE 29. This enlarged view of one of the resupinate sporophores shown in the previous photograph shows several characteristics for this type of *Fomes annosus* fruiting body. The *Poria*-like characters of this form are evident. In addition, note the white, smooth, nonporoid nature of the margin of the fruiting body. The pores of the pore-bearing surface of this conk are comparatively large and are visible to the unaided eye.

Loose pine needles have become embedded in the fruiting structure by the developing conk, which has grown around and enveloped them. In this way pine needles and other debris often become embedded in the conk tissue.

This conk was on a red pine bolt near the bottom of a pile of wood on an infection center. By avoiding piling wood on an infection spot for any length of time, the formation of many *Fomes annosus* fruiting bodies will be prevented.

Renewed Conk Growth

The perennial nature of *Fomes annosus* conks is often apparent in the renewal of growth from conks that had formed the previous year. Some of these new growth forms seem to be a transition from the resupinate form of conk to the bracket type.

FIGURE 30 shows some resupinate *Fomes annosus* conks on the roots of Douglas-fir killed by the disease.

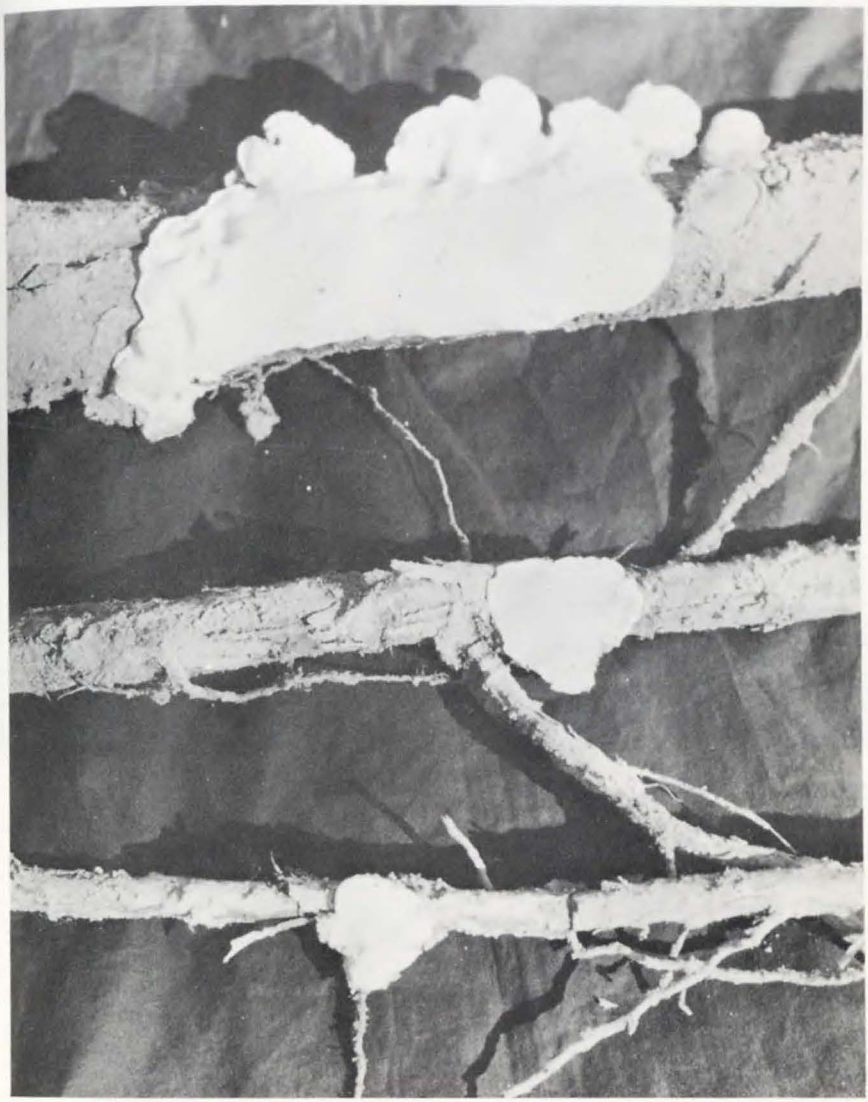
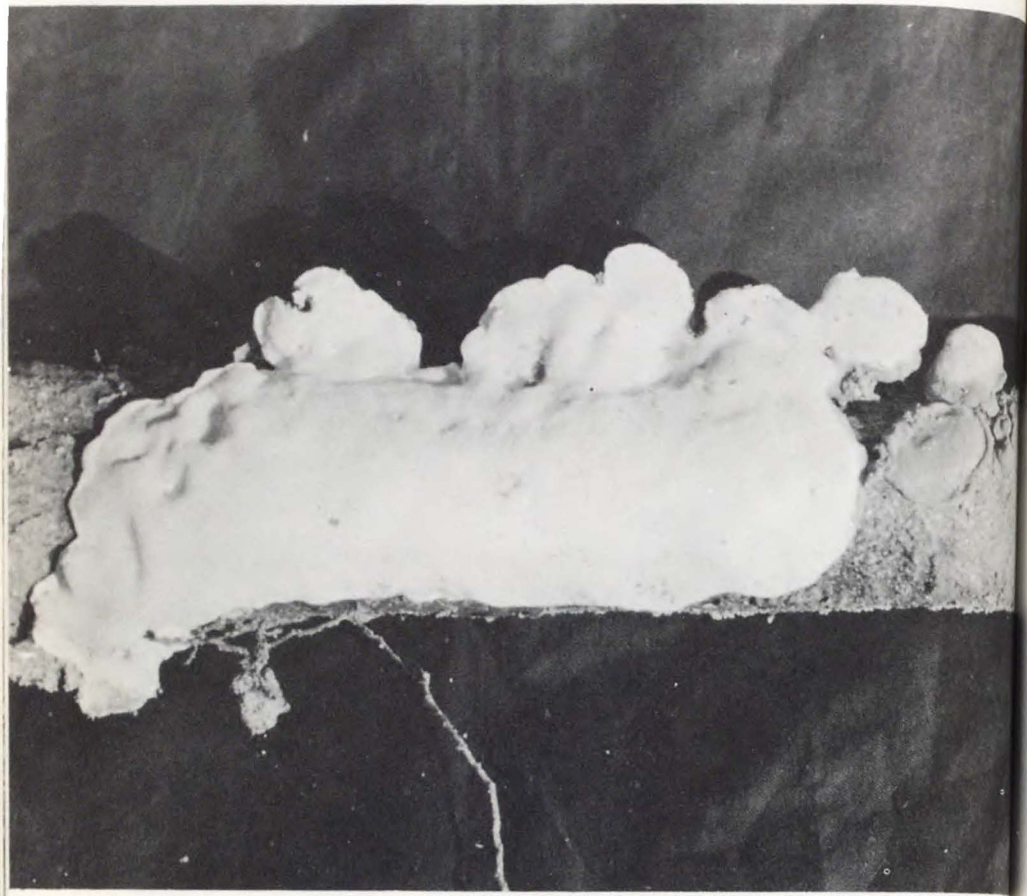


FIGURE 31. The largest of the conks shown in Figure 30 is presented close-up here so it may be examined in greater detail. It can be seen that the conk edge has become mostly reflexed, tending toward the bracket-type form of *Fomes annosus*. In this respect the conk bridges the gap between the strictly resupinate and bracket types of fruiting bodies.



Observe the small separate conks on the upper right. At the right is a small, hemispherical, white mass of tissue in an early stage of development. It exemplifies the pustule type of fruiting. One can see that it originated from the brownish, darker disc which, during the previous season, was a small, round, resupinate conk. This whitish part is renewed growth from last year's conk. Just below it is a brown, small, circular conk formed the previous year, from which growth has not been resumed. The root itself has a sandy covering, this is soil sticking to the resin that oozed from the infected root.

A Few Last Words

It would be premature at this time to make general recommendations for control of the disease caused by *Fomes annosus*. It is one thing to know how to find and recognize the fungus. It is quite another thing to recognize the problems that remain, and to devise control measures applicable for the whole Northeastern Region and for the different tree species attacked by the disease. Lines of attack on some of the problems presented by the disease apparently depend on disease conditions in individual stands.

Much attention is being paid to *Fomes annosus* in present research programs. Through this research we hope to acquire knowledge about the various hosts of the fungus in the Northeast; about the relative susceptibilities of different hosts; about factors that influence the severity of disease attack, including species mixtures, site, and soil factors. We hope that through research it will be possible to devise control methods that can be used to reduce or prevent damage from the disease. As new knowledge is acquired, it will be published.

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